Volume Title: Imports of Manufactures from Less Developed Countries

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Volume Publisher: NBER

Volume ISBN: 0-870-14485-5

Volume URL: http://www.nber.org/books/lary68-1

Publication Date: 1968

Chapter Title: Factor Intensities in the United States

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Chapter URL: http://www.nber.org/chapters/c4978

Chapter pages in book: (p. 18 - 50)

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FACTOR INTENSITIES IN THE UNITED STATES

The Factor-Proportions Theorem

If it is agreed that the less developed countries need to generate a large and growing volume of exports of manufactures to developed countries, the next question is what products best lend themselves to this purpose. The "factor-proportions" theorem identified with Heckscher and Ohlin provides a persuasive, but much disputed, answer to this question.[1] According to that theorem, countries may be expected to have a comparative advantage in goods requiring relatively large inputs of the particular factors of production—whether labor, capital, or natural resources—with which they are most liberally endowed and, correspondingly, a comparative disadvantage in the production of goods embodying their scarce factors. A given country would therefore export goods of the first type and import goods of the second type, on the assumption that there are no hindrances to the flow of trade. In the context of the present study this would mean that, apart from industries based on such natural resources as they might have, the less developed countries would tend to specialize in labor-intensive goods and to import capital-intensive goods. More developed countries with greater capital resources and a highly skilled labor force would show the opposite pattern, at least in their trade with less developed countries.

Plausible though it sounds, the factor-proportions theorem has been severely criticized. Some of the points made against it—notably its

[1] Eli Heckscher's contribution, originally published in the Swedish journal *Ekonomisk Tidskrift* in 1919, appeared in English thirty years later under the title "The Effect of Foreign Trade on the Distribution of Income" (in *Readings in the Theory of International Trade,* Philadelphia, 1949, pp, 272–300). Midway between, in 1935, Bertil Ohlin's major work was published, *Interregional and International Trade* (Cambridge, Mass.), in which he paid particular tribute to Heckscher as well as to other economists of the Stockholm group.

shortcomings as an explanation of the complexities of trade in advanced manufactures—are probably more relevant to trade among the developed countries than to their trade with less developed countries. More generally disturbing is certain empirical evidence which seems to run counter to what the theorem would lead one to expect. Most famous of all is the Leontief paradox—i.e., his finding that the United States, though obviously using more capital per worker than other countries, exports labor-intensive goods and imports capital-intensive goods.[2] This upside-down result is frequently cited in support of alternative approaches to the explanation of trade and is regarded by some, though not by Leontief himself, as demolishing the Heckscher-Ohlin approach.

In the real world, tariffs, subsidies, quotas, and the like do interfere with the flow of trade and are one reason, along with others, for questioning the significance of any of the tests of the factor-proportions theorem which have been attempted.[3] The present analysis does not aim at providing such a test. The methods employed and results found do, however, bear on the validity of the theorem in two important respects:

First, the variable here used as a guide to factor intensities in different industries—i.e., value added per employee in manufacturing—permits an integrated treatment of the flows of services rendered by capital and labor in manufacturing. This contrasts with most previous studies in which the contribution of capital is measured as a stock rather than as a flow of services, and that of labor merely by total man-hours or man-years without regard to differences in skills.

Second, the international comparisons made on this basis support the assumption, crucial to the factor-proportions theorem, that the ranking of industries by factor intensities is much the same from country to country, even from the most developed to the least developed. That is to say, the phenomenon of "factor-intensity reversals" seems to be much less common, at least in manufacturing, than some other empirical studies would suggest.

[2] Leontief judged the factor intensity of U.S. imports by the capital/labor ratios found for U.S. import-competing production, but he interpreted his results more broadly. See, for instance, his remarks on page 343 of his original article (W. Leontief, "Domestic Production and Foreign Trade: The American Capital Position Re-examined," *Proceedings of the American Philosophical Society,* September 1953).

[3] To what extent do Leontief's findings reflect the influence of factor proportions at home and abroad on the composition of U.S. trade, or to what extent do they reflect, much less paradoxically, the effects of U.S. commercial policy? The latter influence is strongly stressed by W. P. Travis in *The Theory of Trade and Protection,* Cambridge, Mass., 1964.

These points form the subject matter of Chapters 2 and 3. They lead, at the beginning of Chapter 4, to a detailed identification of labor-intensive industries in which, presumably, the less developed countries might expect to find their comparative advantage in international trade.

Value Added per Employee as a Guide to Factor Intensity in Manufacturing

Economists have long recognized that differences in the quality of labor largely reflect differences in the amount of training and other forms of investment in people, but it is only in recent years, particularly through the work of Schultz and Becker,[4] that the concept of human capital has begun to be incorporated into the general framework of economic analysis. Most empirical work on factor intensities in different industries and countries has consequently been in terms of the stock of physical capital per worker and has failed to take account, except qualitatively, of the contribution attributable to different levels of skill.[5]

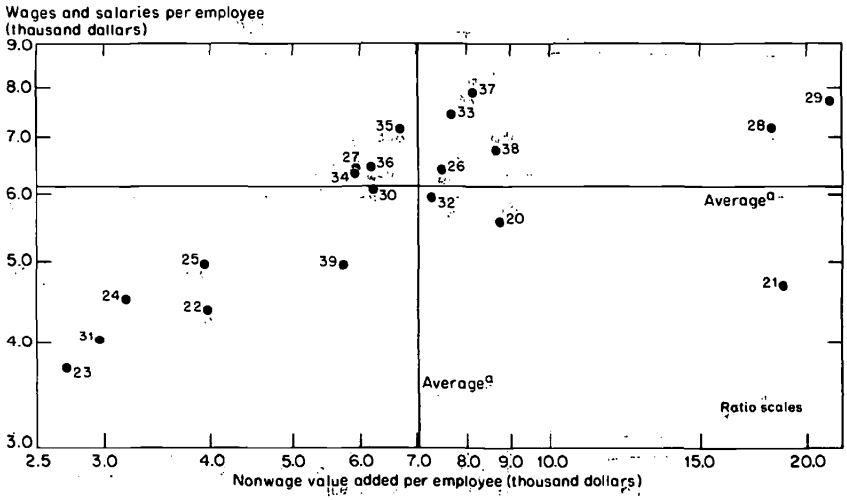
A similar, and perhaps not unrelated, failure can be seen in the actual direction of investment activity in the less developed countries. Thus, Schultz, noting the emphasis on physical capital in loans by the World Bank and the Export-Import Bank, as well as in private investment, comments: "This one-sided effort is under way in spite of the fact that the knowledge and skills required to take on and use efficiently the superior techniques of production, the most valuable resource that we could make available to them, is in very short supply in these underdeveloped countries. Some growth of course can be had from the increase in more conventional capital even though the labor that is available is lacking both in skill and knowledge. But the rate of growth will be seriously limited. It simply is not possible to have the fruits of a

[4] These contributions include T. W. Schultz, "Investment in Human Capital," *American Economic Review,* March 1961, and Gary S. Becker, *Human Capital,* New York, National Bureau of Economic Research, 1964. More recently, Peter B. Kenen has presented an integrated treatment of both human and physical capital in a theoretical model of international trade in "Nature, Capital and Trade," *Journal of Political Economy,* October 1965. Kenen concludes his article with a brief empirical application to factor proportions in U.S. foreign trade in relation to the Leontief paradox, these empirical results being developed more fully in a paper prepared jointly with Elinor B. Yudin, "Skills, Human Capital and U.S. Foreign Trade," International Economics Workshop, Columbia University, 1965 (mimeographed).

[5] An early exception was Edwin Chadwick's effort more than a century ago to estimate the increase in productivity of workers attributable to education. See William L. Miller, "The Economics of Education in English Classical Economics," *Southern Economic Journal,* January 1966.

CHART 1

Wage and Nonwage Value Added per Employee in U.S. Manufacturing by Major Industry Groups, 1965



Source: 1965 *Annual Survey of Manufactures,* U.S. Bureau of the Census.
Note: For names of industry groups, see Table 2.
[a] Average for all U.S. manufacturing industry.

modern agriculture and the abundance of modern industry without making large investments in human beings." [6]

The method used here for measuring, or at least approximating, inputs of both human capital and physical capital on a common basis will be briefly illustrated by reference to Chart 1 and then considered more fully along with various qualifications. The data plotted in the chart are from the U.S. Census of Manufactures and consist of "value added by manufacture" in twenty major industry groups, separated into (a) wages and salaries and (b) the remainder, each of these components being divided by total employment in each industry. Put very loosely, "value added by manufacture" is what remains after subtracting the value of materials consumed from the gross value of output in any given industry or industry group.[7] Differences from industry to

[6] Schultz, "Investment in Human Capital," p. 16. One may, however, detect an increasing emphasis on technical assistance, training programs, educational loans, and other contributions to human capital.

[7] A more precise definition of the concept as applied in the United States is: "Value added by manufacture is derived by subtracting the total cost of ma-

industry in value added per employee are here assumed to measure differences in the aggregate flows of services from the factors of production employed in the manufacturing process (and exclude therefore indirect factor inputs such as materials used). It is further assumed that these services may be ascribed either to human capital or to physical capital, and that, in interindustry comparisons, the wage-and-salary part of value added is a good proxy for the first and the remainder of value added a good proxy for the second. For convenience, the wage-and-salary part will be referred to hereafter in this study as "wage value added" and the remainder as "nonwage value added," but it is to be noted, as further stressed below, that salaries are included along with wages in the first.

This procedure assumes that there is no such thing in reality as completely "unskilled labor," and that, if average earnings are the same in two industries, the average level of human capital per worker is also equal, even though the dispersion around the average is much wider in one case than in the other. For purpose of analysis, however, it is helpful to think of the labor force as if it were composed of units of completely unskilled labor to each of which is added, according to the industry, varying amounts of skill or human capital (vertical axis of Chart 1) and of machinery and other physical assets (horizontal axis).[8] The higher the value added per employee, the more capital-intensive the industry on both accounts combined; the lower the value added per employee, the more labor-intensive the industry.

terials (including materials, supplies, fuel, electric energy, cost of resales, and miscellaneous receipts) from the value of shipments (including resales) and other receipts and adjusting the resulting amount by the net change in finished products and work-in-process inventories between the beginning and end of the year." Note that the costs subtracted from value of shipments do not include purchased services, to wit: "purchases of services from nonmanufacturing enterprises, such as contract costs involved in maintenance and repair, services of development and research firms, services of engineering and management consultants, advertising, telephone and telegraph expense, insurance, royalties, patent fees, etc." (Citations are from *1963 Census of Manufactures,* Vol. I, Summary and Subject Statistics, U.S. Bureau of the Census, 1966, pp. 22–23.

[8] The approach taken here thus differs from the traditional way of measuring the relative labor or capital intensity of different industries in terms only of physical capital per worker or the share of payroll in value added by manufacture. Such measures do not differentiate between labor of different qualifications and implicitly treat managers, scientists, engineers, foremen, and workers of varying skills all on the same basis. Victor R. Fuchs, however, arrived at results broadly similar to those given here by using both the share of wages in value added and average wage per production worker as guides to the relative labor intensity of different industries. See his *Changes in the Location of Manufacturing in the United States Since 1929,* New Haven, 1962, pp. 164–167 and Table 6:11.

Array of U.S. Industries by Value-Added Criterion

On this approach, the industry groups falling in the lower left sector of Chart 1 may be thought of as intensive in the use of relatively unskilled labor, since they are below the United States average in both wage and nonwage value added per employee. Their products include not only textiles and clothing but also lumber and wood products, furniture, leather and leather goods, and a miscellaneous group comprising a wide variety of items. These main industry groups are relatively homogeneous in that very few of their component industries fall outside the boundaries indicated. An interesting exception in the textile group is tufted carpets, a mechanized product which contrasts with the more labor-intensive woven carpets.

Industries in the upper right sector of the chart include two which are extremely capital-intensive by both criteria employed here—chemical products and petroleum refining. Also far to the right in the chart is the tobacco industry, ranking very high in nonwage value added, though low on the wage scale. Here again there is a high degree of homogeneity in the component industries of these major groups. An exception of some relevance for present purposes is the labor-intensive manufacture of cigars, which contrasts with the much larger and more capital-intensive cigarette branch of the industry.

The eleven remaining major industry groups fall closer to the over-all average of wage and nonwage value added for all U.S. manufacturing. They are also much more diverse in composition by these criteria, as indicated by the supplementary detail for selected three- , four- , and five-digit industries in Table 2. Some of the latter fall well within the capital-intensive sector—for example, blast furnaces and steel mills, primary nonferrous metals, automobiles, tires and tubes, pulp mills and paperboard mills, hydraulic cement, flat glass, alcoholic beverages, flour mills, sugar refining, and some other food processing industries. Other components fall well within the labor-intensive sector, including a number of items of interest in the present analysis—rubber shoes, motorcycles and bicycles, cutlery and various other metal products, pleasure craft and other small boats, glass containers, chinaware and pottery, ceramic tiles, canned seafood, canned fruit and vegetables, paper and paperboard containers, and various kinds of printed matter and printing services.

This allocation leaves a number of other industries and products near, or beyond, one or the other of the limits suggested by Chart 1 for the labor-intensive sector, among them being metal castings and stamp-

TABLE 2

Supplementary Detail on Employment and Value Added in U.S. Manufacturing by Main Industry Groups and Selected Subgroups, 1965

SIC Code	Industry Group or Subgroup	Total Employment (thousands)	Value Added by Manufacture ($ million)	Value Added per Employee (percentage of national average)		
				Total	Wages and Salaries	Other
	U.S. manufacturing, total[a]	16,900.6	222,283	100	100	100
20	Food and kindred products	1,635.0	23,383	109	91	124
2013	Meat processing plants	48.3	611	96	102	91
2031	Canned and cured seafoods	15.7	191	93	68	114
2033	Canned fruits and vegetables	99.7	1,174	90	66	110
2041	Flour Mills	20.7	403	148	105	186
2062	Cane sugar refining	11.2	276	188	124	243
2071	Confectionery products	65.2	723	84	74	94
208	Beverages	210.5	4,141	150	104	189
20943	Animal and marine oil products, including fats	2.0	24	84	77	123
21	Tobacco manufactures	75.1	1,768	179	77	269
2111	Cigarettes	35.9	1,366	289	90	463
2121	Cigars	20.9	220	80	59	98
22	Textile mill products	891.5	7,469	64	72	57
2211	Weaving mills, cotton	205.4	1,624	60	70	51
225	Knitting mills	231.2	1,644	54	63	46
2271	Woven carpets and rugs	10.6	109	78	83	74
2272	Tufted carpets and rugs	26.6	376	108	76	135

(continued)

TABLE 2 (continued)

SIC Code	Industry Group or Subgroup	Total Employment (thousands)	Value Added by Manufacture ($ million)	Value Added per Employee (percentage of national average)		
				Total	Wages and Salaries	Other
23	Apparel and related products	1,311.8	8,427	49	61	39
24	Lumber and wood products	569.7	4,388	59	73	46
25	Furniture and fixtures	407.7	3,620	68	81	56
26	Paper and allied products	605.6	8,400	105	104	107
2611	Pulp mills	14.3	336	178	124	226
2621	Paper mills, except building	131.7	2,043	118	118	117
2631	Paperboard mills	64.8	1,391	163	119	202
264[b]	Paper and paperboard products	155.7	1,908	93	94	92
2647	Sanitary paper products	19.1	418	166	104	221
265	Paperboard containers and boxes	208.7	2,136	78	96	62
2661	Building paper and board mills	11.3	169	114	104	123
27	Printing and publishing	962.8	11,888	94	104	85
2732	Book printing	37.3	396	81	108	57
275	Commercial printing	321.1	3,304	78	106	54
2771	Greeting card manufacturing	24.6	254	78	87	71
278	Bookbinding and related work	47.4	404	65	83	49
2791	Typesetting	21.0	223	81	129	39
28	Chemicals and allied products	776.2	19,721	193	117	260
29	Petroleum and coal products	143.5	4,154	220	126	303

(continued)

TABLE 2 (continued)

SIC Code	Industry Group or Subgroup	Total Employment (thousands)	Value Added by Manufacture ($ million)	Value Added per Employee (percentage of national average)		
				Total	Wages and Salaries	Other
30	Rubber and plastics products, n.e.c.	461.3	5,657	93	99	88
3011	Tires and inner tubes	88.7	1,602	137	132	142
3021	Rubber footwear	30.0	247	63	76	51
3069	Rubber products, n.e.c.	139.2	1,594	87	100	76
3079	Plastics products, n.e.c.	201.4	2,189	83	86	79
31	Leather and leather products	332.5	2,325	53	66	42
32	Stone, clay, and glass products	598.8	7,922	101	97	104
3211	Flat glass	25.3	463	139	132	145
3221	Glass containers	61.5	680	84	95	74
3241	Cement, hydraulic	34.3	837	186	115	247
3253	Ceramic wall and floor tile	12.6	112	68	85	53
326	Pottery and related products	41.6	376	69	86	53
33	Primary metal industries	1,242.6	18,759	115	121	110
331	Steel rolling and finishing	638.4	10,507	125	127	124
332	Iron and steel foundries	224.7	2,562	87	112	64
333	Primary nonferrous metal	52.5	1,225	177	115	232
335	Nonferrous rolling and drawing	174.3	2,565	112	117	108
336	Nonferrous foundries	74.6	804	82	105	62
34	Fabricated metal products	1,160.2	14,208	93	103	84
34211	Cutlery, scissors, shears, etc.	7.3	63	72	84	61
3423	Hand and edge tools	35.2	456	98	99	98
3425	Hand saws and saw blades	5.7	81	108	104	112

(continued)

TABLE 2 (continued)

SIC Code	Industry Group or Subgroup	Total Employment (thousands)	Value Added by Manufacture ($ million)	Value Added per Employee (percentage of national average)		
				Total	Wages and Salaries	Other
	Fabricated metal products (cont'd)					
3429	Hardware, n.e.c.	97.4	1,290	101	106	96
343	Plumbing and heating, except electric	70.8	855	92	99	86
344	Structural metal products	344.6	3,976	88	103	75
3451	Screw machine products	39.0	419	82	103	63
3452	Bolts, nuts, rivets, and washers	62.2	848	104	113	95
3461	Metal stampings	147.0	1,655	86	102	72
35	Machinery, except electrical	1,651.5	22,819	105	116	95
3552	Textile machinery	41.2	412	76	98	57
3572	Typewriters	18.6	298	122	102	139
3599	Miscellaneous machinery	147.7	1,662	86	104	69
36	Electrical machinery	1,604.5	20,222	96	105	88
3631	Household cooking equipment	20.9	268	98	98	97
3632	Household refrigerators	48.7	748	117	115	118
3633	Household laundry equipment	21.0	386	140	109	167
3634	Electric housewares and fans	40.9	542	101	84	116
3635	Household vacuum cleaners	6.5	131	153	102	198
3636	Sewing machines	6.9	90	99	117	84
3639	Household appliances, n.e.c.	13.9	229	125	104	145
3642	Lighting fixtures	62.2	740	90	93	88

(continued)

TABLE 2 (continued)

SIC Code	Industry Group or Subgroup	Total Employment (thousands)	Value Added by Manufacture ($ million)	Value Added per Employee (percentage of national average)		
				Total	Wages and Salaries	Other
	Electrical machinery (cont'd)					
3651	Radio and TV receiving sets	102.5	1,213	90	86	93
3661	Telephone, telegraph apparatus	101.9	1,362	102	113	92
367	Electronic components	317.7	3,321	79	91	69
3694	Engine electrical equipment	43.2	584	103	109	97
37	Transportation equipment	1,732.4	27,727	122	128	116
371	Motor vehicles and equipment	821.9	16,495	153	131	171
372	Aircraft and parts	642.3	8,493	101	133	72
3732	Boatbuilding and repairing	28.1	213	58	78	41
3742	Railroad and street cars	40.7	539	100	114	88
3751	Motorcycles, bicycles, and parts	11.2	107	72	90	57
38	Instruments and related products	327.7	5,046	117	110	124
382	Mechanical measuring devices	99.6	1,362	104	109	100
3841	Surgical and medical instruments	15.2	189	95	95	95
3851	Ophthalmic goods	22.3	215	73	82	66
38611	Still picture equipment	17.9	227	107	137	80
38613	Motion picture equipment	7.6	69	77	116	41
38615	Photographic sensitized film and plates	26.5	626	200	152	244
3871	Watches and clocks	29.0	340	89	90	89
3872	Watchcases	3.5	29	63	86	43

(continued)

TABLE 2 (concluded)

SIC Code	Industry Group or Subgroup	Total Employment (thousands)	Value Added by Manufacture ($ million)	Value Added per Employee (percentage of national average)		
				Total	Wages and Salaries	Other
39	Miscellaneous manufacturing	410.0	4,380	81	81	82
391	Jewelry and silverware	48.1	520	82	88	77
3931	Musical instruments and parts	23.6	231	74	86	64
394	Toys and sporting goods	119.7	1,088	69	72	67
395	Pens, pencils, and office supplies	33.4	378	86	86	87
396	Costume jewelry and notions	52.1	479	70	84	91

Source: *Annual Survey of Manufactures, 1965: General Statistics for Industry Groups and Industries,* U.S. Bureau of the Census, Washington, 1966; *1963 Census of Manufactures: Industry Statistics,* U.S. Bureau of the Census, Washington, 1966.

Note: All five-digit items are from *1963 Census of Manufactures* and, in the last three columns, are related to the national averages for that year. N.e.c. = not elsewhere classified.

[a]Operating establishments only, excluding administrative and auxiliary units. National averages in 1965 used as base in last three columns are total value added per employee, $13,152; wages and salaries, $6,136; other, $7,016.

[b]Excluding SIC No. 2647, sanitary paper products.

ings; hardware and tools; plumbing and heating equipment; household fans, automotive electrical equipment, radio and television sets, and other light electrical goods; sewing machines and typewriters; various types of machinery; surgical and medical instruments; some measuring or scientific instruments; and watches and clocks.[9]

As will be noted later, most of the items just enumerated are marginal also in the sense that exports by less developed countries form only a very small part of international trade in these goods. They are nevertheless of particular interest, since these products could be next in line for the achievement of an export potential by some of the less developed countries as the growth of their experience and capacity in manufacturing permits them to move beyond the more strongly labor-intensive types of production. And one may further observe that, to judge by the data for these industries in the last two columns of Table 2, the development of labor skills (including managerial experience and technical abilities) seems no less important than the growth of physical capital, if this kind of evolution is to occur.

The Content of Value Added

Taken literally, the assumption that interindustry variations in value added by manufacture per employee reflect differences in the aggregate value of services rendered by human and physical capital would imply fully competitive factor and product markets in which the marginal contribution of these services is precisely matched in each case by the rewards paid. This condition is, however, only imperfectly realized at best because of various market interferences, some short-run and others of longer duration. These need to be noted as well as certain deficiencies or peculiarities of the statistics which may also affect interindustry difference in value added per employee.

Among the short-run influences, the business cycle is no doubt the most important and pervasive through its influence on profits and, to a lesser extent, on wage rates. Since some industries are more sensitive than others to cyclical fluctuations, interindustry differentials in value added per employee may reflect the phase of the business cycle pre-

[9] Some of these items are included in the above list on the basis of similar data from earlier U.S. censuses of production because of changes in the products in recent years. Thus, typewriter production now includes fewer manual and more electric models, with the result that value added per employee in this industry in 1965 was 22 per cent above the national average for all manufacturing, whereas in 1947 it was 12 per cent below the average. Domestic output in such cases would no longer be indicative of the factor intensities of imported types.

vailing at the time the observations are made as well as capital intensities. In fact, however, comparison of value added per employee in the prosperous year 1965 and in the recession year 1958 shows a high, positive correlation, the coefficient of correlation for 406 industries at the four-digit level being 0.94 (R^2 adjusted = 0.87). One may therefore conclude that, except perhaps in more extreme circumstances, the meaningfulness of the value-added approach to the measurement of capital intensity does not require major qualification for the effects of the business cycle.

Profit rates may vary from industry to industry for numerous other reasons. As Stigler says, "The sources of disequilibrium are infinitely varied. . . . All leave their impact upon the rates of return, and we can, in fact, turn our analysis around and define the fluctuations in an industry's profit rate as the measure of the extent and duration of disequilibrium." [10] Among the causes of disequilibrium, differences in the extent of concentration—i.e., in the relative importance of a few large companies—are frequently thought to have a substantial effect on interindustry differences in rates of return and profit margins, "monopoly profits" being enjoyed by the more strongly concentrated industries. To the extent that this is so, the profit element in nonwage value added would tend to vary across industries with the extent of concentration.[11]

Not only profit differentials but also wage differentials may arise because of greater monopolistic tendencies in one industry than in another. Workers in some industries are much more strongly organized than in others, and one would expect unionization to have an effect on relative wage levels.[12] Differences in wages also occur because some

[10] George J. Stigler, *Capital and Rates of Return in Manufacturing Industries,* Princeton University Press for National Bureau of Economic Research, 1963, p. 64.

[11] A monograph in preparation by Norman R. Collins and Lee E. Preston ("Concentration and Price-Cost Margins in Manufacturing Industries") notes "a significant, although weak association between concentration and corporate profits" in most previous analyses based primarily on U.S. concentration data for 1954. Their own analysis of 1958 data leads them to report a significant association (though, paradoxically, weaker at the more detailed four-digit industry level than at the broad two-digit level). Noting that 1954 and 1958 were both years of mild recession and also that profits of smaller firms show greater cyclical instability than those of large firms, Collins and Preston consider that the association between concentration and profits may be a recession phenomenon (though not unimportant for that reason), but do not exclude other possibilities pending the results of analysis of the data for 1963.

[12] In connection with his study of the service industries for the National Bureau, Victor R. Fuchs finds that differences in unionization (measured as the fraction of total employment in each industry covered by collective bargaining agree-

industries are growing faster than others and seek to attract labor; thus for short periods observed wages are disequilibrium values. Still other differences in wages are to be explained because nonmonetary utilities or disutilities are greater in some industries than in others, or perhaps simply because tradition irrationally bestows higher earnings on some activities than on others.[13]

The essential question is, however, whether or not the various influences noted in the labor and capital markets are so strong and pervasive as to impair the general usefulness of value added per employee as a guide to the capital intensity of different industries.

Before this topic is further explored, still another question needs to be clarified; that is, how much violence is done to reality in proceeding as if all contributions to value added in manufacturing could be attributed either to human capital or to physical capital.[14] Since it is obtained as the difference between the cost of material inputs and the value of output, value added by manufacture is not regularly and systematically broken down in the Census of Manufactures into its main components. The only important exception is payroll of operating establishments, which permits the division here made between wage and nonwage value added.[15]

Conceptually, there should not be any difficulty about seeking to relate wages to the gross return on human capital. The problem would

ments) help to explain earnings differentials among industries. His provisional "best" estimate is that, over the range from 20 to 60 per cent of unionization, an increase of one percentage point in unionization is associated with an increase of approximately 0.8 cent in hourly earnings, taking 138 goods and services industries together. Fuchs qualifies his results by noting that they may not measure the effects of unionization alone but may also reflect quality differences among workers not adequately taken into account in his analysis.

[13] At a meeting of the OECD Study Group in the Economics of Education, J. Sandee of the Central Planning Office, The Hague, maintained that "people are paid according to what they 'ought' to have, rather than according to what they individually produce"; among the more decisive influences he mentioned "custom and tradition, arbitrary decisions copied by whole industries, relative trade union strengths [and] considerations of 'fairness.'" "Comments on Mr. Edward F. Denison's Paper," in *The Residual Factor and Economic Growth*, OECD, Paris, 1964, p. 75.

[14] In considering this question we need not be concerned (at least for the time being) with the contribution of natural resources, since value added by manufacture excludes the input of materials.

[15] The Census reports show, for each industry, both total payroll for all employees and total wages for production workers only, along with the aggregate numbers in each case. It is the more comprehensive series which is used here, so that throughout this study "average wage" should be understood to mean average earnings per employee, covering both wage earners and salaried personnel.

seem to be concentrated rather in the catchall residual, nonwage value added, which would include not only the gross return on physical capital but payments to various other factors as well (except those subtracted out with material inputs). Indeed, as indicated by the estimates in Table 3 for manufacturing as a whole in 1957, these payments even include several streams of rewards to labor not in the regularly reported payroll item. These are items 2, 3, and 4 in the table, i.e., wage supplements, payrolls of central administrative offices and other nonmanufacturing divisions of multiunit companies, and the estimated labor income of proprietors of unincorporated manufacturing businesses.[16]

Of the remaining items in the table, those numbered 5 to 10 would all seem to have a fairly close connection with capital assets. This may even be true of some of the elements (such as royalty payments and patent fees), though not of others (notably advertising, further discussed below) in the ultimate residual group III in the table. Capital-related payments thus seem to account for close to $40 billion, or about 60 per cent, of nonwage value added in 1957. On the assumption that other elements in nonwage value added are randomly distributed by industries, it would seem reasonable to think of interindustry differences in nonwage value added per employee as largely reflecting differences in the intensity of capital inputs, and to try to test this relation.

The separation between wage and nonwage value added may be, however, unduly restrictive for purposes of measuring the industry pattern of capital inputs per employee. As noted, nonwage value added includes certain elements (such as item 4 in Table 3) which may be identified with human capital, though without necessarily following the same industry distribution as the payroll of operating establishments. This may hold also for some of the elements of the final residual, notably, contract research and possibly legal and other professional services. It may not be a disadvantage therefore that nonwage value added is conceptually broader than physical capital, though there is little possibility of relating it empirically to any of the other inputs. One can only conjecture that some of these inputs may have a systematic relation, not necessarily the same as that of physical capital, to different

[16] An industry breakdown is available only for item 2, wage supplements, and in this case only for 1957 as the result of a special survey of selected costs (see *1958 Census of Manufactures,* Vol. I, pp. 9–3—9–23). Payments of the nature covered by item 3 of the table, as well as many of those indicated for the residual group III, are company-type expenditures and cannot be reported on an establishment basis by companies consisting of more than one establishment. It must be assumed, however, that these expenses are reflected in value of shipments and, hence, in value added by manufacturing establishments.

TABLE 3

Partial Breakdown of Value Added in All U.S. Manufacturing Enterprises, 1957

($ billion)

Total value added by manufacture	147.8
I. *Payroll and Other Rewards to Labor, Total*	91.9
1. Payroll of operating establishments	76.4
2. Supplements to payroll	6.0
3. Payroll in central administrative offices, sales departments, and auxiliary establishments	7.0
4. Imputed salaries of proprietors of unincorporated firms[a]	2.5
II. *Expenses Related to Physical Assets, Total*	37.5
5. Pretax corporate profits	22.1
6. Depreciation	7.3
7. Maintenance and repair services purchased from other firms	4.5
8. Property taxes	1.5
9. Insurance	.7
10. Rents	1.4
III. *All Other Expenses, Total*[b]	18.4

Source: *1958 Census of Manufactures*, Vol. I, pp. 13 and 14, supplemented by information provided by the Industry Division, Bureau of the Census, except as noted in footnote a with respect to item 4.

[a]Rough estimate based on unpublished tabulations for Irving Leveson's National Bureau study of self-employment derived from *U.S. Census of Population and Housing: 1960, 1/1,000*. According to these tabulations, self-employment income received by proprietors of unincorporated manufacturing businesses in 1959 amounted to some $4 billion. Allowing for returns to property and allowing also for growth from 1957 to 1959, this implies that returns to labor of proprietors were between $2 billion and $3 billion in 1957.

[b]This item, obtained by difference, is presumed to include expenditures for advertising, publicity, legal services, travel and communications, royalty payments, patent fees, purchases of research and advisory services from outside firms, other professional services, bad debts, entertainment, and miscellaneous other expenses.

industries. To the extent that they do, it would enhance the usefulness of total value added per employee as a guide to capital intensity, broadly viewed, even though the division of the total into its wage and nonwage components yields only an imperfect measure of inputs of human and physical capital separately considered. It will be seen in the following two sections that, in fact, the two components appear to provide reasonably good indications of these inputs.

Wages and Human Capital

Recognizing that undifferentiated man-years were a crude way of measuring labor inputs into different industries, Leontief introduced in his second article on U.S. factor proportions a table showing labor requirements distributed by five broad skill groups in export industries and in import-competing industries.[17] This comparison showed a significantly larger concentration of higher skills in the first than in the second array of industries. He made the further point, relevant to the methodology followed in this analysis, that "The measurement of labor inputs in terms of wages paid reflects the same distinction, insofar as it amounts to weighting in the process of aggregation the man-years of each skill group by its respective average annual wage rate." [18]

Leontief did not apply either of these measures to his factor proportions analysis, but he did remark in passing that his table on skill levels confirmed and possibly explained Kravis' findings that average wage rates in U.S. export industries were systematically higher than those prevailing in import-competing industries.[19] Kravis had found that hourly wages in 330 U.S. manufacturing industries in 1947 were higher the greater the ratio of exports to domestic production and, conversely, were lower the greater the ratio of imports to domestic production.[20] The difference in average hourly wages was 15 per cent in 46 leading export industries compared with 36 leading import-competing industries (weighted by the amount of trade in 1947 in each case).

Taking her cue from these results, Helen Waehrer confirmed by various tests that average wages were significantly higher also in 1960

[17] W. Leontief, "Factor Proportions and the Structure of American Trade: Further Theoretical and Empirical Analysis," *Review of Economics and Statistics,* November 1956, p. 399.

[18] *Ibid.,* p. 394.

[19] *Ibid.,* p. 399, note 8.

[20] Irving B. Kravis, "Wages and Foreign Trade," *Review of Economics and Statistics,* February 1956, pp. 14–30.

in export industries than in import-competing industries.[21] In explanation of these differences, Mrs. Waehrer offered the dual hypothesis (a) that average wages varied from industry to industry with skills, and (b) that skills were higher in export industries than in import-competing industries. To test this hypothesis, she constructed two measures of skill with data from the 1960 Census of Population, an "occupational index" and an "educational index," and related each of them to average earnings, computed from the 1960 Survey of Manufactures, in 35 broad industry groups significantly involved in foreign trade.[22] She found a significant correlation between each of these indexes and earnings and also, by either index, a substantially higher level of skills in export industries than in import-competing industries.

The first part of Mrs. Waehrer's hypothesis being of primary interest for present purposes, it is preferable to consider her data relating the two skill indexes to average annual wages in all of the 59 industry groups distinguished by the Census of Population for the manufacturing sector.[23] Each of the indexes suffers from certain limitations as a measure of skill or human capital. The occupational index varies from industry to industry only with differences in the distribution of employees between occupations treated as skilled and those treated as unskilled, and wide variations in skill may be concealed within each of these two very broad categories. The educational index covers only formal schooling, not on-the-job training and experience. Moreover, strict comparability cannot be assured in compressing the industrial classification used in the Census of Manufactures, the source of the

[21] "Inter-industry Skill Differences, Labor Earnings and United States Foreign Trade, 1960" (unpublished Ph.D. dissertation, Columbia University, 1966).

[22] The "occupational index" is defined as the percentage of employees in each industry falling in six occupational groups selected by Mrs. Waehrer as skilled (professional and technical workers; managers, officials, and proprietors; clerical and kindred workers; sales workers; craftsmen and foremen; and service workers) out of a total labor force including two groups treated as unskilled (operatives and kindred workers, and laborers except farm and mine). Her "educational index" is defined as the median years of formal schooling completed by employees in each industry weighted by the sex composition of the industry. Since Mrs. Waehrer was interested in studying the wage structure of export industries and import-competing industries, she confined her selection of industries to those in which exports or imports were above the over-all average ratios to the value of shipments in all manufacturing industry. Those meeting this criterion included 22 defined as export industries and 22 defined as import-competing industries, with an overlap of nine, i.e., a total of 35 out of the 59 industry groups into which manufacturing is divided in the Census of Population.

[23] Mrs. Waehrer has kindly made available her computations for the 24 industry groups additional to those counted as export industries or as import-competing industries and reported on in her dissertation.

earnings data, into the fifty-nine industries given in the Census of Population. Not only are the classifications different but also the individual employee, in responding to the Census of Population questions, may place himself in a different industry than that given by his employer's plant report to the Census of Manufactures.

Since there is no apparent reason to suspect a systematic bias in these various deficiencies, all the more interest attaches to the correlation coefficients obtained: 0.78 between annual earnings and the occupational index, and 0.76 between annual earnings and the educational index (59 observations), both measures being significant at the 1 per cent level of confidence and attesting to a meaningful association between wages and skills across industries. The variables used in the correlation of earnings and the occupational index are plotted in Chart 2 and are identified by industries (along with those plotted in Chart 3) in Appendix Table A-1.

The two skill indexes prove to be a poor guide to earnings in newspaper publishing and printing, as the occupational index is also for other kinds of publishing and printing. These two industries account for the extreme deviations in the upper right area of Chart 2.[24] Since neither of them could be regarded as typical of manufacturing, it has seemed useful to recompute the regressions excluding these industries. The result is to raise the correlation coefficient to 0.85 for the occupational index and to 0.79 for the educational index.

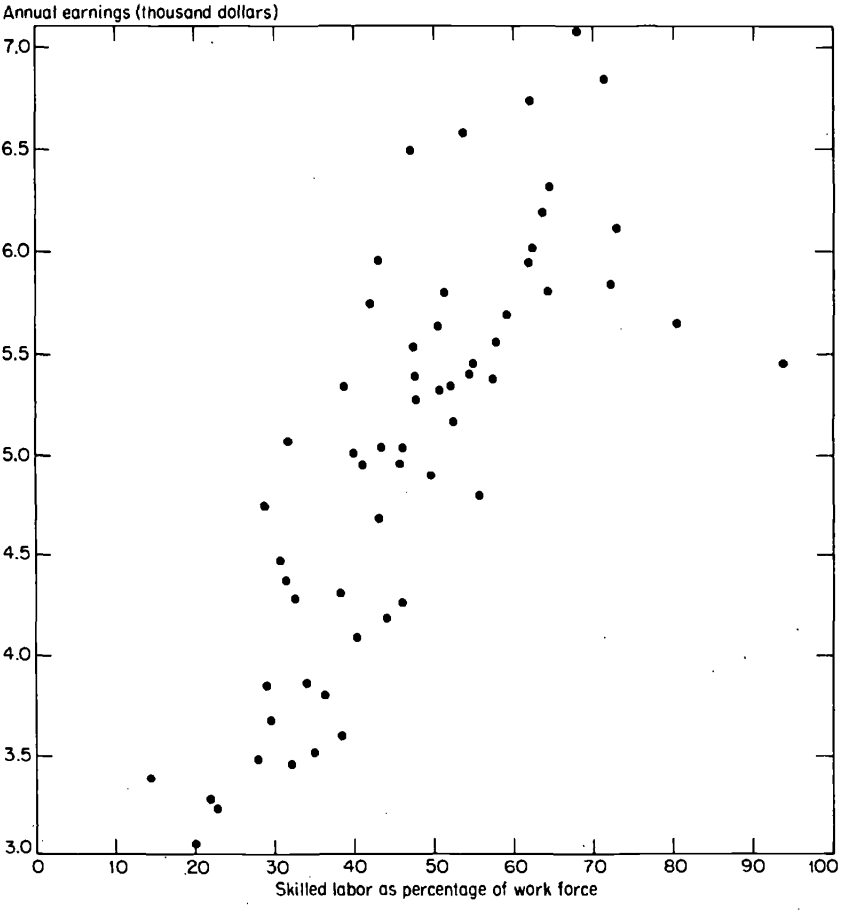
Yet a third measure of variations in the quality of labor among the same 59 manufacturing industries is available as a by-product of the National Bureau's study of productivity in the service industries. This measure takes the form of estimates of "expected" hourly earnings in 1959 on the basis of data given by the one-in-a-thousand sample from the Census of Population in 1960. These are the average earnings that would be found for each industry if each worker's earnings were equal to the national average for his particular color, age, sex, and level of education (workers being classified into 168 cells according to these characteristics). Significant differentials in national average earnings associated with each of these variables suggest that they reflect, at least in part, differences in human capital.[25]

[24] Part of the explanation, at least, is that newsboys, who form a large part of total employment in the newspaper business as reported by the Census of Population, are counted by the later as "sales workers" and, in turn, enter into the skilled category of Mrs. Waehrer's occupational index.

[25] See Victor R. Fuchs, *Differentials in Hourly Earnings by Region and City Size, 1959,* New York, NBER, 1967. Regarding the color variable, Fuchs notes (p. 5) that "The white-nonwhite differences are probably due in part to market

CHART 2

Average Annual Earnings and the "Occupational Index" in 59 Industry Groups in the United States, 1960



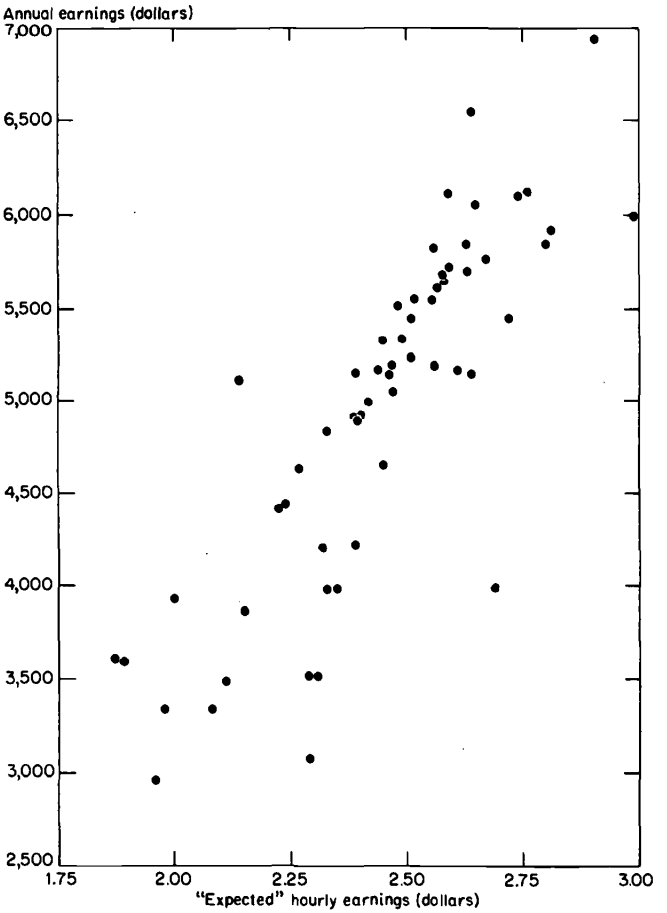
Source: See Appendix A.

Chart 3 relates the "expected" average hourly earnings in the 59 industries to actual average annual earnings in 1959, derived from the same Census of Population sample. The reason for choosing the annual rather than the hourly series as the variable for analysis is that all other wage series used in this study from censuses of manufactures for

discrimination, but color is relevant to quality because of the likelihood that, at given levels of education, nonwhites have received poorer-quality schooling and less on-the-job training than have whites."

CHART 3

Average Annual Earnings and "Expected" Hourly Earnings in 59 Industry Groups in the United States, 1959



Source: See Appendix A.

the United States and other countries are on an annual basis,[26] and it is these figures which need to be tested as a guide to the intensity of

[26] The U.S. Census of Manufactures, as well as those for most other countries, reports total payroll and total numbers for all employees and for production workers separately, but gives total man-hours for the latter group only. One must therefore choose between (1) working with average annual earnings or (2) applying the derived man-hours per production worker to salaried employees also. Neither course is fully satisfactory, but probably there is little difference

different industries in inputs of human capital. Correlation coefficients computed between both hourly and annual earnings and expected hourly earnings are 0.79 and 0.84, respectively, both results being significant at the 1 per cent level of confidence (59 observations).

A slightly stronger relation is found, on both bases, when the variables are weighted according to sample size (or, more precisely, according to total man-hours worked in the sample for each industry), which tends to reduce the influence of erratic elements attributable to the small coverage of some industries. This procedure raises the correlation coefficient for hourly earnings to 0.81 and that for annual earnings to 0.85. These results give further support to the hypothesis that interindustry differences in average wages, though undoubtedly influenced by unionization and other forces, largely reflect differences in human capital. They are in line with Schultz's hypothesis that "most of the differences in earnings are a consequence of differences in the amounts that have been invested in people," and that "the structure of wages and salaries is primarily determined by investment in schooling, health, on-the-job training, searching for information about job opportunities and investment in migration." [27]

Nonwage Value Added and Physical Capital

The next question is to see how close a relation there is between nonwage value added and physical capital per employee. It has been suggested above that the first concept, though broader, is not therewith necessarily less useful than the second. Another advantage of the nonwage-value-added criterion is that, being a "flow" rather than a "stock" figure, it fits better with the notion of factor inputs into production and with the theory of production functions. Though the use

for present purposes, since annual wages and hourly wages computed from the aggregates for production workers are very closely correlated. A linear correlation coefficient of 0.98 is found for 412 U.S. industries at the four-digit level in 1963, and a linear correlation of the two variables for 100 Indian industries in 1961 yields the same coefficient, both results being significant at the 1 per cent level of confidence.

The interindustry variance is greater, however, in annual than in hourly earnings in U.S. manufacturing and is positively related to interindustry differences in skills. This result arises largely because of the generally shorter hours worked by female than by male employees and the relative concentration of female employment in apparel and other low-skill industries. This explains why a higher correlation coefficient is obtained with annual earnings than with hourly earnings as the dependent variable.

[27] T. W. Schultz, "Reflections on Investment in Man," *Journal of Political Economy,* Supplement, 1962.

of the estimated stock of capital is a more conventional measure of the physical capital intensity of different industries, the stock figures may not closely reflect the flow of services from capital into the production process.[28]

The uncertainty regarding the stock figures is compounded by the familiar vintage problem, i.e., the fact that available data on capital assets include equipment and buildings acquired at various times past and at different price levels and written down according to depreciation practices varying among industries and influenced by changing tax laws. It can be argued that it is better to think of the flow of services rendered by a stock of capital as being spread evenly over its lifetime, and hence to use the original undepreciated book values. This procedure, however, fails to meet the problem that investment outlays have to be recouped much faster from some types of equipment than from others and faster from equipment in general than from buildings.

Fortunately, the data on capital assets in different industries at the end of 1957 obtained by a special survey in connection with the 1958 Census of Manufactures make it possible to use the figures both before and after deducting depreciation and depletion. Inventories can also be added in and an allowance made for rented assets on the basis of data reported on rents paid.[29] The outcome is that a meaningful association is found between nonwage value added per employee and physical assets per employee, with assets measured either gross or net. Using the logarithms of these variables for 276 four-digit industries, the coefficient of correlation is 0.81 on the first basis and 0.80 on the second, both results being significant at the 1 per cent level of confidence.[30]

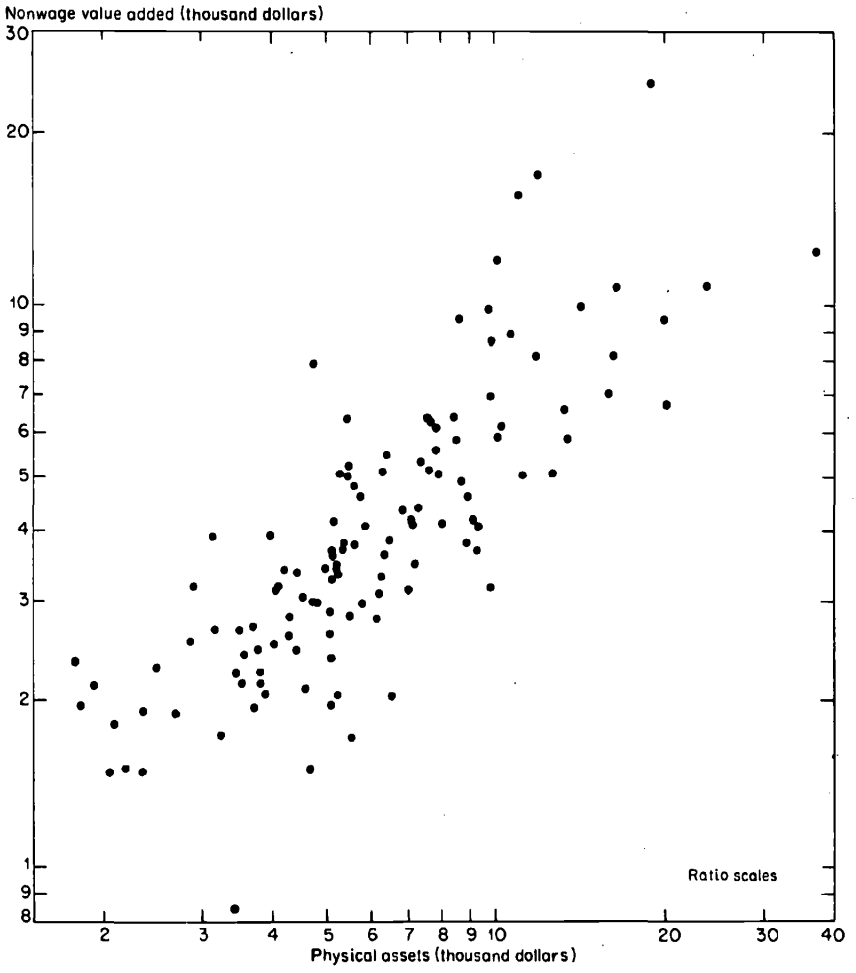
[28] For a discussion of the problems encountered in working with data on the stock of capital as inputs into production, see Edward F. Denison, *The Sources of Economic Growth in the United States and the Alternatives Before Us,* New York, 1962, pp. 94–98.

[29] The gross-assets series used here consists of the sum of (1) gross book value of fixed assets at the end of 1957, (2) inventories at the end of 1957, and (3) rentals paid during 1957 multiplied by 7 to approximate the capital value of the rented assets. The net series used consists of the foregoing minus the sum of (4) accumulated depreciation to the end of 1956 and (5) depreciation charged during 1957. For a fuller statement of sources and methods, see Appendix A.

[30] There is no economic theory to determine a priori the correct functional form, arithmetic or logarithmic, for these correlations. Use of the arithmetic form presumes that there is a relation between the absolute differences from industry to industry in each of the two variables (i.e., physical assets per employee and nowage value added per employee), and use of the logarithmic form presumes that there is a relation between the percentage differences from industry to industry in each of the variables. Appendix A gives the results of a test for linearity and a test for homoscedasticity, or homogeneity of variance, undertaken to help in judging the appropriate form of correlation.

CHART 4

Nonwage Value Added and Net Physical Assets per Employee in U.S. Manufacturing by 122 Three-Digit Industries, 1957



Source: See Appendix A.

The net-assets series is plotted against nonwage value added per employee in Chart 4 (covering 122 industries at the three-digit level), and both of these series are reproduced in Table A-2 (also covering three-digit industries only).[31]

[31] At the three-digit level (122 industries) the coefficients of correlation are 0.80 with assets on a gross basis and 0.81 with assets on a net basis.

Advertising and Other Influences on Value Added

Advertising expenditures are, as previously mentioned, among the purchased services reflected in nonwage value added by manufacture, and differences from industry to industry in the one may help to explain differences in the other. This influence could scarcely be a dominant one, since total advertising expenditures reported to the Internal Revenue Service by manufacturing corporations for 1957–58 amounted to $4.4 billion, not all of which would be allocated to their manufacturing establishments and included in the $55.9 billion of nonwage value added shown (for 1957) in Table 3.[32] Advertising outlays are, however, concentrated in certain industries, notably foods, tobacco, drugs and chemicals, and electrical appliances and machinery, these four major groups accounting for almost half of the total cited for 1957–58. Whether considered as current expenditures or as an indication of likely past advertising and of the return realized on investment in good will, advertising may make up more of value added in the industries in question than it does in others and, in such cases, would weaken the reliability of value added per employee as a measure of capital intensity.

This supposition seems to be borne out by Table 4, covering industries in which nonwage value added per employee exceeds by a wide margin (i.e., by more than two standard errors) what would be expected on the basis of their physical assets. These industries all belong to the groups just mentioned. Their advertising expenditures, with the sole exception of electric lamps, also appear very high in relation to physical assets, on the basis of data drawn from Internal Revenue sources. Unfortunately, the two sets of data are not closely comparable, not only because of differences in coverage but also because of the more summary nature of the IRS classification. As a result, the rate of advertising outlays in breakfast cereals, chewing gum, and cigarettes, for example, would no doubt be greatly understated in the data for the broader groups with which these products are merged in the IRS list. If allowance is made for these effects, it seems clear that advertising expenses help to explain the wider deviations noted, on the high side, in nonwage value added compared with physical assets.[33] The number of such

[32] On the other hand, the figure of $4.4 billion would not include advertising by unincorporated manufacturing firms. Data are from *Statistics of Income—1957–58,* Corporation Income Tax Returns, Washington, 1960, p. 26.

[33] It would be more to the point to show advertising per employee, rather than in relation to assets, but employment is not reported on the corporate tax returns underlying the Internal Revenue statistics. The Bureau of the Census has, however, compiled from its own (establishment) records 1958 employment figures for "matched corporations" accounting for 91 per cent of total receipts of corporations in the IRS universe. (See especially Table 7 in *Enterprise Statistics:*

TABLE 4

Manufacturing Industries with Exceptionally High Nonwage Value Added per Employee (1957) and High Advertising Expenditures (1957–58) in Relation to Physical Assets

Data on Establishment Basis Used in Census of Manufactures				Data on Company Basis Used in Internal Revenue Reports				
	Nonwage Value Added per Employee							
SIC Number and Industry Name[a]	Actual Average (dollars) (1)	Indicated by Assets (dollars) (2)	Ratio of 1 to 2 (per cent) (3)	IRS Number and Industry Name[b]		Advertising Expenditures ($ million) (4)	Physical Assets ($ million) (5)	Ratio of 4 to 5 (per cent) (6)
All manufacturing	4,876	–	–	All manufacturing		4,424	130,205	3.4
2043 Cereal breakfast foods	13,190	4,229	312	207	Cereal preparations	26	165	15.8
2052 Biscuits and crackers	7,460	3,279	228	204	Bakery products	111	874	12.7
2073 Chewing gum	16,579	6,596	251	206	Confectionery and related products	54	416	13.0
2091 Leavening compounds	17,747	5,972	297	208-9	Other food and kindred products[c]	243	1,357	17.9
2111 Cigarettes	24,158	9,921	244	211	Tobacco products, excl. cigars[d]	210	2,086	10.1
2834 Pharmaceutical preparations	16,440	6,030	273	282	Drugs and medicines	255	1,012	25.2
2841 Soap and glycerin	20,449	7,624	268	283	Soap and glycerin cleaning and polishing preparations	173	494	35.0
2842 Cleaning and polishing products	13,529	5,948	227					
2893 Toilet preparations	17,589	5,045	349	285	Perfumes, cosmetics, and other toilet preparations	108	164	65.9
3584 Vacuum cleaners	9,438	4,234	223	362	Electric appliances	25	272	9.2
3651 Electric lamps (bulbs)	7,898	3,214	246	365	Electric lamps	0.4	13	3.1
3663 Phonograph records	8,442	3,587	235	366	Radio, radar, and television equipment and phonographs	100	1,371	7.3

Notes to Table 4

Source: For nonwage value-added data, see Appendix A. Data on advertising and physical assets are from *Source Book of Statistics of Income* for 1957-58.

[a]Standard Industrial Classification prior to 1957 revision.

[b]Adaptation of SIC by Internal Revenue Service.

[c]Combined from No. 208, "other food, including manufactured ice and flavoring syrups," and No. 209, "food and kindred products, not allocable." It is to be noted that these two miscellaneous subgroups account for about 16 per cent of fixed assets and about 30 per cent of advertising in the food group in 1957–58 and are very much broader than SIC 2091, with which they are paired in this table.

[d]Listed as "other tobacco products."

deviations is relatively few, though a similar relation to advertising would no doubt be found for some other industries, including some of the apparel group, if less extreme deviations were also examined.

Some of these industries, as well as others showing relatively high nonwage value added per employee, would also have large research and development outlays and large central office expenses.[34] High rates of return on capital are a further important influence. Thus, Stigler estimated the rate of return, after tax, in 1957 at 7.28 per cent in tobacco products, 5.60 per cent in motor vehicles, 4.68 per cent in chemicals, and 4.71 in electrical machinery and equipment, compared with an average rate of return of 3.81 in all manufacturing industry.[35]

1958, Part 3, "Link of Census Establishment and IRS Corporation Data," Series ES 3, No. 3, Washington, 1964.) On the basis of these figures, it may be roughly estimated that advertising expenditures per employee in 1957–58 were in the order of $2,500 in drugs and medicines, $4,000 in soap and other cleaning and polishing preparations, and $3,500 in perfumes, cosmetics, and toilet preparations (these calculations being confined here to those industries for which the product coverage in the IRS series does not appear to be significantly wider than that of the four-digit items from the Census of Manufactures with which they are matched in Table 4).

[34] Research and development work done outside the manufacturing establishment may be (1) purchased as a service from other firms, or (2), in the case of multiestablishment firms, conducted by the central office and costs allocated back to the individual producing units. In either event, the costs would tend to be reflected in higher nonwage value added in these units. Similarly, other central office expenses would be allocated to the producing units and reflected in their value added.

[35] George J. Stigler, *Capital and Rates of Return in Manufacturing Industries*, Princeton for NBER, 1963 (see especially Table 2 of errata statement issued July 6, 1964). It should be noted that the rates of return in Stigler's study are computed in relation to all corporate assets (except investments in other companies) and would be larger in relation to physical assets only.

Differential rates of return on investment may also help to explain downward deviations in observed compared with expected nonwage value added per employee. As may be seen in Table A-2, the textile and wood products industries figure prominently in this group, a position consistent with Stigler's estimated average rate of return in 1957 of only 1.38 per cent in textile mill products and 1.16 per cent in lumber and wood products. In addition, the amount of value added reported by textile manufacturing establishments producing "gray goods" may be held down by the allocation of profits from finishing the fabric (i.e., bleaching, dyeing, and printing) to sales or head offices.[36] And in some of the wood products industries value added may appear relatively low because of the inclusion of timber holdings in assets. More generally, multifirm companies benefiting from depletion allowances in their tax returns may find it advantageous to shift profits from the manufacturing to the raw-material phase of their business, a factor which would tend to reduce value added in petroleum refining and in various of the primary metal industries and nonmetallic mineral industries.

These various explanations and qualifications, along with those noted previously, need to be kept in mind in any attempt to measure and compare the capital intensity of different industries, but they do not argue uniformly in favor of the use of either the stock or the flow series. The fact that the two series are significantly correlated does, however, tend to strengthen confidence in both of them. Support of nonwage value added per employee as a measure of capital intensity in different industries is particularly helpful in view of the greater availability of this kind of information for other countries, and for past periods in the United States, through censuses of manufactures.

Supporting Data from India

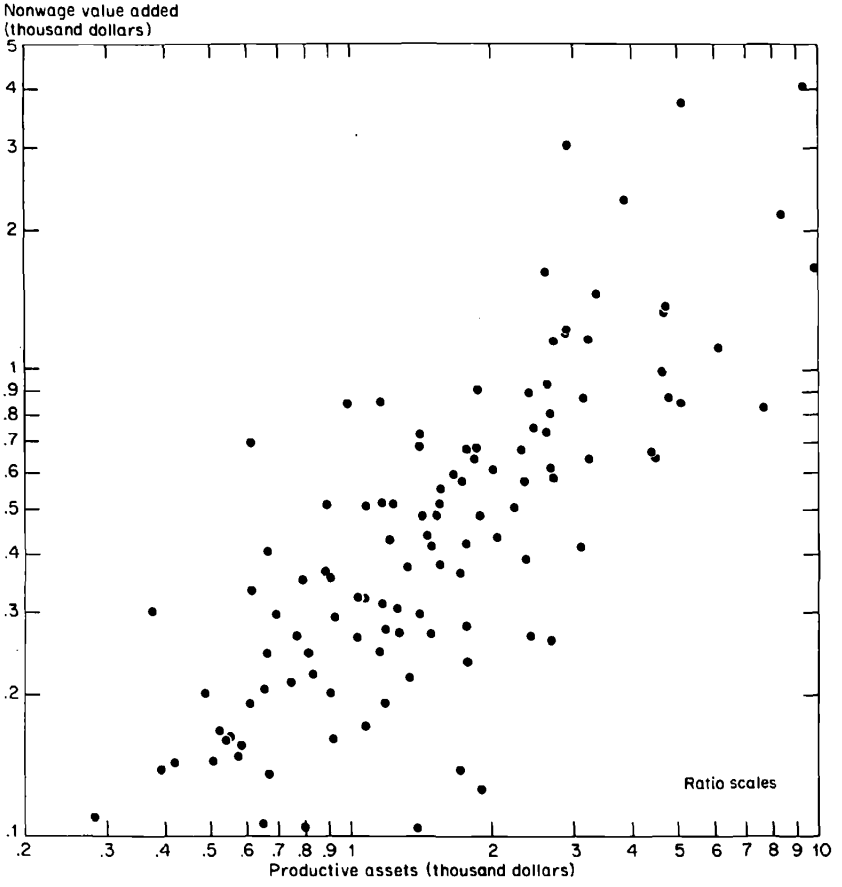
Assets data for another country of special interest in this study, India, are available by detailed industry breakdown and can be compared with nonwage value added per employee in the same manner as for the United States. These variables for 115 Indian industries in 1961 are given in Chart 5.[37] In logarithmic form, the coefficient of

[36] For a brief description of the way the production process is divided and organized, see section on "Dyeing and Finishing Textiles, except Wool Fabrics and Knit Goods," *1963 Census of Manufactures,* Vol. II, Pt. 1, pp. 22C—1–4.

[37] Two of the 117 industries used in the comparison of India and the United States in the next chapter (see Chart 13) are omitted here. Their inclusion would raise the correlation coefficient quoted above to 0.87 (or to 0.91 in a linear regression). This result is attributable, however, to the undue influence of one

CHART 5

Nonwage Value Added and Net Productive Assets per Employee in 115 Manufacturing Industries, India, 1961



Source: See Appendix A.

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of the omitted industries, petroleum refining, for which both productive assets and nonwage value added per employee are extremely high in India—$33,827 and $8,244, respectively. The second omitted industry, carpet weaving, is at the other end of the scale and is very low in productive assets per employee in India, $585, and lower still, relatively speaking, in nonwage value added, $61 (though data for 1962, which have subsequently become available, indicate that the relative size of these two variables—$609 and $155, respectively—is much closer to that given by the regression equation).

correlation between these two variables is 0.78.[38] These results thus provide additional support for the use of nonwage value added per employee as a guide to interindustry differences in the intensity of capital inputs.

Indirect Inputs and the Role of Natural Resources

The use of value added by manufacture as a guide to capital requirements per employee is subject to the possible criticism that it takes into account only direct inputs into manufacturing. Perhaps, as Leontief endeavored to do in his oft-cited computations of physical capital per employee in United States foreign trade,[39] we should also include indirect capital and labor inputs into growing, digging, or otherwise producing the materials used in manufacture. This still would not make flour or meat or cement labor-intensive and probably none of the metals, whose material inputs tend to be intensive in capital (along with natural resources, which Leontief was unable to incorporate in his analysis). But some other products might show rather different capital-labor ratios if indirect factor inputs into materials are counted along with direct inputs into the processing or manufacturing phase.

Even if true, the point is scarcely relevant to a consideration of comparative advantage in different manufacturing industries insofar as the materials needed are readily transportable internationally. In all such items competition takes place in the world's commodity markets, and countries which do not themselves produce the materials can import them. To include indirect factor inputs in these cases fits ill with the very purpose of explaining international specialization and trade. It assumes, for instance, that Japan or Hong Kong produces not only the cotton textiles which they export but also the raw cotton embodied in these exports, or that the United Kingdom itself produces the crude oil entering into its exports of refined products.[40] The more appropriate procedure would surely be to count only direct inputs into manufactur-

[38] With reference to footnote 30 above, see Appendix A for the results of tests for linearity and for homoscedasticity made to assist in determining whether the arithmetic or the logarithmic form of correlation is appropriate.

[39] Leontief, "Domestic Production and Foreign Trade," and "Factor Proportions and the Structure of American Trade."

[40] In the summary record of an international conference on these and related issues, Bertil Ohlin is reported as "very worried that 98 per cent of reasoning in international trade theory was based on the assumption that the whole of a good was produced in one country. Countries did import raw materials and export semimanufactures." From Roy Harrod (ed.), *International Trade Theory in a Developing World,* London, 1963, p. 398.

ing in considering the influence of factor intensities on the location of such industries.[41]

Resource-Oriented Manufacturing Industries

Some primary products are, however, too perishable or too bulky to bear transportation costs over long distances without first undergoing some processing. This is particularly true of certain foodstuffs, notably fresh fish, fruit, and vegetables.[42] In such products the location of the processing industries is determined far more by the availability of the material inputs on the spot than by the relative requirements and supplies of capital and labor for processing the materials. At least for these industries, therefore, one needs to push the question back one stage and ask what determines the location of primary production. An answer must allow for the influence of soil, climate, and other natural conditions and encounters the familiar difficulty of distinguishing and measuring the contribution of natural resources on the same basis as that of labor and capital.[43]

In passing, it may be recalled that the unavoidable absence of natural resources in Leontief's simplified two-factor model is one of the most crucial and most criticized features of his analysis of factor proportions in United States foreign trade, and one which leaves his paradoxical findings of uncertain significance.[44] The problem is, fortunately, of much more limited importance in the present inquiry, which omits primary products altogether and focuses on labor-intensive manufactures. At least a rough and impressionistic judgment can be attempted for those few labor-intensive manufactures which also appear to be strongly resource-oriented. These items will be included in the trade flows

[41] This is also the view expressed by Donald B. Keesing in "Labor Skills and International Trade: Evaluating Many Trade Flows with a Single Measuring Device," *Review of Economics and Statistics,* August 1965, pp. 287–294.

[42] Even in these groups select qualities destined for high-income markets may move to distant points by swift air or surface transport.

[43] This problem is explored at length by Jaroslav Vanek in *The Natural Resource Content of United States Foreign Trade, 1870–1955,* Cambridge, Mass., 1963. Vanek found it necessary to work with what he defined as "resource products" rather than with resource requirements.

[44] This view was strongly expressed in several early commentaries on Leontief's results, including those by Boris C. Swerling, "Capital Shortage and Labor Surplus in the United States," *Review of Economics and Statistics,* August 1954; Norman S. Buchanan, "Lines on the Leontief Paradox," *Economia Internazionale,* November 1955; Irving B. Kravis, "Availability and Other Influences on the Commodity Composition of Trade," *Journal of Political Economy,* April 1956; and M. A. Diab, *The United States Capital Position and the Structure of its Foreign Trade,* Amsterdam, 1956.

examined in Chapter 4 only if the availability of low-cost labor seems to be decisive in determining the location of the primary production to which the processing is tied by transportation costs.

For present purposes, it seems plausible to assume that the natural conditions governing the supply of fish, fruit, and vegetables are not peculiar to only a few of the less developed countries, compared with others or with more developed countries, and that the production of these inputs as well as their processing into transportable form is decisively influenced by the supply of low-cost labor.[45] These products in canned or preserved form, along with certain other food products less closely tied to the local production of material inputs, are accordingly treated here as labor-intensive. The same assumption is not made, it may be noted, with respect to meat and meat products, which are supplied mainly by Argentina among the less developed countries and reflect a heavy natural-resource input into range-fed cattle. In this case and others like it, it is the resource factor that determines the location of the primary production and, therewith, the location also of the processing industry.

Outside the food group, there are only a few other industries where the location of labor-intensive manufacturing seems to be fairly closely tied to local sources of the material inputs. These concern mainly various extracts and materials of vegetable origin usually classed with chemicals: tanning extracts; medicinal and pharmaceutical products; and essential oils, perfume, and flavoring materials (items 532, 541, and 551 of the Standard International Trade Classification). Only with regard to the last of these groups is it here assumed that the supporting primary production is predominantly influenced by the supply and cost of labor, though even in this case some of the important commodities in the group are unique to certain localities.

[45] Peru's striking success since the early 1950's in developing the production and export of fish meal (included here in the selection of labor-intensive manufactures) has, of course, been conditioned upon the usually abundant supply of anchovy brought near its shores by the Humboldt Current. But low labor costs would seem to be decisive in making the product competitive with other low-unit-value animal feedstuffs such as soyabean and meat meal.